Study on complexity of plant communities at different altitudes on the Northern Slope of Changbai Mountain

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Abstract: By the method of gradient pattern analysis, twenty plots were set at altitudes of 700-2600 m with an interval of 100 m on the northern slope of the Changbai Mountain. The dissimilarity of respective sub-plots in the same community was measured and the complexity of plant communities at different altitudes was analyzed. The result from binary data of tree species in canopy tree indicated that the sub-plots in the communities, except subalpine *Betula ermanii* forest, showed comparatively high dissimilarity in species composition. Especially, the dissimilarity index (0.7) of broadleaved/Korean pine forest at low altitudes was obviously higher than other communities. The differences are not obvious between communities referring to dark coniferous forest. Comparatively, the dissimilarity in sub-plots of the communities at altitude of 1400 m was slightly higher than that of other communities, which reflected the complexity of tree species compositions of transitory-type communities. For subalpine *Betula ermanii* forest, tree species composition was simple and showed a high similarity between sub-plots. The results derived from binary data of shrub showed that the dissimilarity index of shrub species in broadleaved/Korean pine forest at low altitudes was higher than that in other communities, but the divergence tendency wasn't so obvious as that of arbor species. The dissimilarity derived from binary data of herb and all plant species at different altitudes showed greatly close tendency, and the differences in herb and all plant species between sub-plots were the greatest for the communities of broad-leaved-Korean pine forest and alpine tundra zone..

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Introduction

The similarity or dissimilarity of plant community structure and composition reflected not only the dissimilarity or diversity of local habitat of the community, but the complexity of the community to a certain extent (Ma 1994). There existed obvious environment gradients and different species composition and richness among vegetation types at different altitudes on the northern slope of Changbai Mountain (Chen 1964; Wang 1980). Previous studies mainly focused on several scattered sampling plots and no research was carried out on the gradient characteristics of vegetation along altitude gradients of Changbai Mountain. Therefore, to date, there has not been detail information about the species diversity varying with the environment gradients and about the process of plant community complexity varying with altitude gradients (Chen 1964; Qian 1992; Zhao 1980; Wang 1980). In this study we measured the dissimilarity of species with a life form and all species among sub-plots of communities at different altitudes, in order to discover the law of community complexity varying along with altitude gradients and provide fundamental knowledge for further research and protection of Changbai Mountain forest ecosystem.

Study area

The vegetation on the northern slope of Changbai Mountain mainly distributed on the slope areas at altitudes of 700 m to 2 600 m, with a total area of 45 km^2 in the level distance. Annually average temperature is 2.8 °C in the area at altitude of 700 m, which has characteristics of typical temperature zone climate, while at the top of the mountain, the annually averaged temperature dropped down only –7.3℃, which showed the features of polar region climate (Chi 1981). Precipitations increase obviously with altitude rising, with an annual average of 680 mm at altitude of 700 m and 1 340 mm at altitude of 2 600 m respectively, and the maximum precipitation (1809 mm) occurred at the top of the mountain (Chi 1981; Zhao *et al.* 1980). With altitude increasing, it presents an obviously vertical zonal spectrum of vegetation. The broad-leaved/Korean pine forest at the lower altitudes (bellow altitude of 1 100 m) is one of the areas of natural mixed forests of conifer/broadleaved in the world. This forest type is characteristic for its complex structure, distinctive composition, and rich biological diversity. The dark coniferous forest, composed mainly by *Picea koraiensis* Nakai and *Abies nephrolepis* Maxim, has the characteristics of typical

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boreal forest and constituted the main body of Changbai Mountain vegetation. Subalpine *Betula ermanii* Cham forest at altitudes of 1 800-2 000 m, composed of single tree species, formed a kind of distinctive subalpine zone forest-landscape. Alpine tundra of Changbai Mountain at altitudes 2 000-2 600 m is a vegetation type particular to China, with the characteristics of Artic tundra (Chen 1964; Qian 1992, Wang 1980).

Study methods

Plot layout

Gradients pattern method was adopted for setting plots from altitudes of 700 m to the top of the mountain (2 600 m). Totally 20 plots were set by setting one plot at every 100-m altitude rising. At altitudes of 700 to 1 900 m, the area of plot was designed as 32 m×32 m. At the alpine tundra zone where the altitude is over 2 000 m, the area of plot was reduced to 16 m×16 m. At altitudes lower than 1 900 m, each 32 m×32 m plot consisted of 16 sub-plots with an area of 8 m×8 m for each; for alpine tundra at altitude of 2 000 m and above, each 16 m×16 m plot consisted of four sub-plots with an area of 8 m×8 m for each.

Items and methods of investigation

Altitude, slope, exposure, forest crown density, total shrub coverage, and total herb coverage, etc. were recorded, and correspondingly geographical position sketchy graph of plots was drawn. We took sub-plot as investigation unit. For the trees lower than 1.3 m, we recorded the species, heights, and growing conditions, while for trees higher than 1.3 m, species name, diameter at breast high, growing conditions (perishing or normal) were recorded and height was measured by eyes. We also recorded the species, abundance, average height, plant number, and conditions of local habitat (such as growing on fallen trees or in opening) for shrub and herb.

Community complexity

Community similarity index, or dissimilarity index, used to descript the similarity or dissimilarity of communities or habitats, reflects the complexity of community to a certain extent. Dissimilarity index (Zhang 1984) is defined as:

$$CD = 1 - \frac{2c}{a+b} \quad (1)$$

where: *CD* (Community dissimilarity) is community dissimilarity index; *c* is the number of species in common between two communities; *a, b* are species numbers of two communities respectively. Obviously, *CD* is similar to Wilson and Shimida index: β_T (Magurran 1988). Furthermore, the sum of *CD* with SΦrensen' community similarity index is 1.

Data were processed by the self-designated program of Qbasic and Excel etc.

Results and analysis

The similarity or dissimilarity of species composition between sub-plots of the same community reflects the heterogeneity and complexity of local habitat of the community. The results derived from the average value of dissimilarity indexes of respective layers between each pair of 8 m×8 m sub-plots at different elevations (Table 1) reflect not only the degree that they have same species among sub-plots in respective communities, but also the species richness and the complexity of community composition.

Fig. 1 further exposed that, according to the data of tree species in canopy, there existed comparatively high dissimilarity between sub-plots at all altitudes, except for subalpine *Betula ermanii* Cham forest (altitude of 1 800-1 900 m). Particularly the average dissimilarity index of broadleaved/Korean pine forest at low altitudes was up to 0.74, obviously higher than other vegetation types, which indicated that tree species compositions of canopy in broadleaved/Korean pine forest was complexity and there existed differences between sub-plots. The differences are not obvious between communities referring to dark coniferous forest. Comparatively, the dissimilarity in sub-plots of the communities at altitude of 1 400 m was slightly higher than that of other communities. It reflected the complexity of tree species compositions of transitory-type communities. *Betula. ermanii* Cham forest, composed of simple tree species composition, also displayed comparatively high similarity between sub-plots.

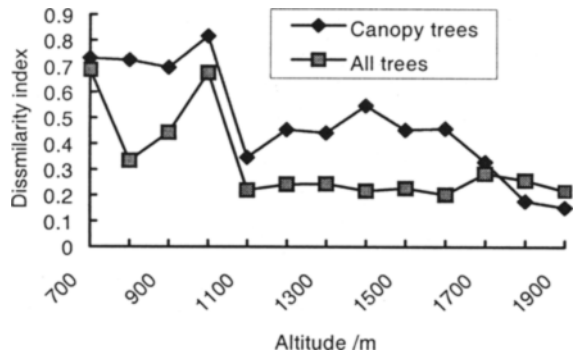

Fig. 1 Dissimilarity index for canopy trees and all trees between sub-plots of communities at different altitudes

The calculated results based on the binary data of all arbor species also showed similar tendency although it was not so obvious as canopy trees. In the two communities at altitudes of 700 m and 1 000 m, the differences of tree species composition are greatest. There was a little dissimilarity between communities over altitude of 1 100 m, with dissimilarity index of 0.2 to 0.3), or between the communities showed high similarity in tree species composition, which was different from that calculated only by tree species in canopy.

Table 1. Dissimilarity index among sub-plots of communities in Changbai Mountain

Elevation	Canopy tree			Tree			Shrub			Herb			All species		
(m)	Mean	SD	Max	Mean	SD	Max	Mean	SD	Max	Mean	SD	Max	Mean	SD	Max
700	0.73	0.28	1	0.69	0.21	1	0.43	0.15	0.82	0.40	0.08	0.6	0.44	0.07	0.59
800	0.72	0.20	1	0.33	0.11	0.60	0.45	0.17	0.75	0.42	0.14	0.71	0.39	0.08	0.58
900	0.70	0.25	1	0.44	0.14	0.83	0.41	0.16	0.85	0.39	0.13	0.7	0.40	0.09	0.63
1000	0.82	0.23	1	0.68	0.21	1	0.43	0.16	0.80	0.45	0.20	1	0.47	0.13	0.87
1100	0.35	0.22	1	0.22	0.11	0.54	0.49	0.28	1	0.30	0.09	0.55	0.30	0.07	0.51
1200	0.45	0.20	1	0.24	0.09	0.50	0.33	0.19	0.78	0.23	0.08	0.46	0.25	0.06	0.39
1300	0.44	0.17	0.75	0.25	0.10	0.54	0.74	0.30	1	0.31	0.11	0.65	0.32	0.08	0.54
1400	0.55	0.28	1	0.22	0.10	0.50	0.48	0.21	1	0.29	0.07	0.50	0.30	0.05	0.42
1500	0.45	0.28	1	0.23	0.13	0.56	0.34	0.16	0.75	0.32	0.06	0.50	0.31	0.06	0.47
1600	0.46	0.30	1	0.20	0.15	0.67	0.23	0.19	0.60	0.21	0.06	0.39	0.21	0.06	0.41
1700	0.33	0.19	0.67	0.29	0.16	0.75	0.38	0.19	0.71	0.31	0.08	0.49	0.31	0.06	0.48
1800	0.18	0.18	0.5	0.26	0.19	0.60	0.33	0.16	0.67	0.35	0.12	0.74	0.34	0.10	0.66
1900	0.15	0.17	0.33	0.22	0.16	0.60	0.18	0.12	0.43	0.30	0.11	0.57	0.25	0.07	0.43
2000							0.20	0.10	0.29	0.47	0.07	0.56	0.39	0.07	0.47
2100							0.23	0.10	0.39	0.53	0.18	0.78	0.41	0.12	0.58
2200							0.20	0.09	0.33	0.24	0.05	0.31	0.23	0.02	0.26
2300							0.13	0.08	0.25	0.28	0.08	0.36	0.25	0.08	0.33
2400							0.37	0.19	0.64	0.23	0.14	0.44	0.29	0.11	0.41
2500							0.12	0.08	0.20	0.23	0.07	0.33	0.20	0.05	0.26
2600							0	0	0	0.09	0.04	0.15	0.08	0.04	0.13

The dissimilarity between sub-plots in communities was also derived from binary data of shrub (Fig. 2). Although the dissimilarity index of shrub species in broadleaved/Korean pine forest at low altitudes was higher than that in other communities, the divergence tendency wasn't so obvious as that of arbor species. In the communities at altitude of 1300 m, the shrub species displayed the greatest difference between sub-plots, with an average dissimilarity index of 0.74. In dark-coniferous forest the shrub species between sub-plots also had bigger dissimilarity. Species number of shrubs was less in dark-coniferous forest, 6-7 species on average in each pot and only one species for minimum, and the coverage was low, so that differences between sub-plots were greater. In alpine tundra zone, the differences in shrub species between sub-plots of communities at different altitudes were all comparatively small, with a dissimilarity index of about 0.2 except for altitude of 2 400 m, and displayed similarity of shrub species composition in tundra.

Calculating dissimilarities between sub-plots of communities by binary data of herbs and all species at different altitudes (Fig. 3) displayed greatly similar tendency. The herbs and all plant species between sub-plots of communities showed differ greatly in both broadleaved/Korean pine forest and alpine tundra zone at altitude of 2 000-2 100 m. Dark-coniferous forest was basically at similar level. Compared with results from data of tree species, the dissimilarity of herbs between sub-plots dropped down sharply, due to more species of herbs in sub-plots and a high proportion of common species between sub-plots, and it is also evident form SD and Max value.

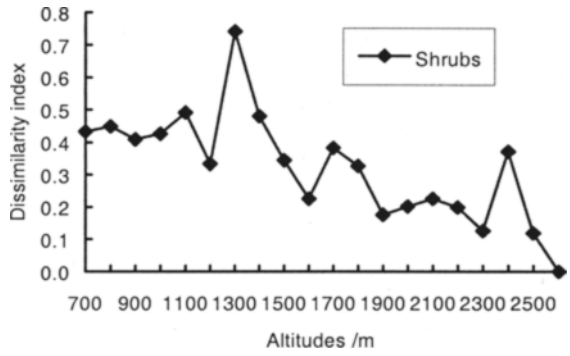

Fig. 2 Dissimilarity index for shrub species between sub-plots of communities at different altitudes

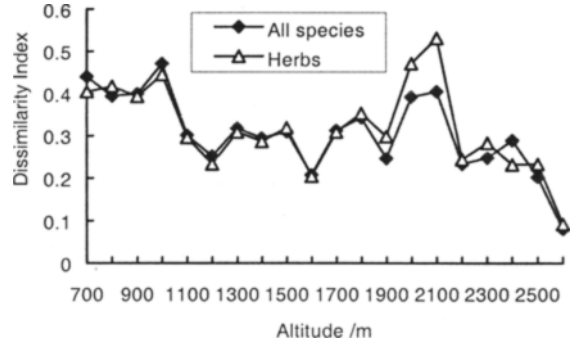

Fig. 3 Dissimilarity index for herb and all species between sub-plots of communities at different altitudes

Discussion

Dissimilarity of species composition between sub-plots in the same community fairly reflected not only Heterogeneity of micro habitat in the community, but also the diversity and complexity of the communities' species composition to a certain extent (Magurran 1988; Ma 1994). High dissimilarity between sub-plots of community indicated that the community has complex species composition, rich diversity, and that species composition was obviously difference and less similarity between sub-plots. As to the community with little dissimilarity between sub-plots, the species composition was greatly similar, similarity of sub-plots was higher, and the species number was less through out the whole community. In broadleaved/Korean pine forest on the northern slope of Changbai Mountain at low altitudes, tree, shrub or herb all had complex species composition, and showed relatively high difference in species composition between sub-plots in the same community. Yet in dark-coniferous forest, all kinds of life form plants had relatively little richness, and the community was composed of few dominant species. For subalpine *Betula ermanii* forest, the herb species was comparatively rich, but species composition of woody plant was greatly monotonous, especially the canopy layer which is consisted of sole dominant species, *Betula ermanii*. In alpine tundra zone, the area of community was the smallest, and species composition of sub-plots was very similar in the same community, with a relative high similarity. The law of dissimilarity of species composition between sub-plots of communities varying along with altitude gradients fairly reflected the pattern of community complexity on the northern slope of Changbai Mountain.

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